# PREFACE

As authors, we are honored to play a key role in the instruction of future generations of zoologists, ecologists, wildlife managers, and other life scientists. We undertook the revision for the eighth edition with this privilege and the responsibility for content integrity in mind.

The preparation of the eighth edition of *Zoology* involved careful evaluation of the previous editions and the features that contributed to the understanding of zoology as an exciting and dynamic scientific field. Our goal in preparing the eighth edition of *Zoology,* as in previous editions, was to prepare an introductory general zoology textbook that we believe is manageable in size and adaptable to a variety of course formats. We have retained the friendly, informative writing style that has attracted instructors and students to previous editions.

The shorter format of previous editions was well received by users as being less expensive and easily adapted to a one-semester course format. The eighth edition retains that format. The shorter format does mean that some general biological topics were eliminated from the book. These chapters are, however, still available, along with numerous other resources, in an electronic format on the book website and are free to adopters of the book. (Chapters found online only are indicated in the Table of Contents by an asterisk.)

## Content and Organization

We have maintained from the inception of this text that evolutionary and ecological perspectives captivate students and are fundamental to understanding the unifying principles of zoology. These perspectives are incorporated into *Zoology* in a number of ways. For example, animal structure and function are considered in the context of the environment, the animal phyla are described in the context of their roles in ecosystems, and most of the "Wildlife Alerts" that first appeared in the fourth edition, and were expanded in the fifth and sixth editions, have been retained. These boxed readings depict the plight of selected animal species or broader ecosystem issues relating to preserving various animal species.

We believe that the eighth edition of *Zoology* presents evolution as an exciting and dynamic field of study—a field of study that is vital for understanding all of biology. In addition, the continuing and expanding pseudoscientific attacks on biology make it a necessity that evolutionary concepts be presented clearly and convincingly throughout the biology curricula. We have attempted to do just that. Animal survey chapters begin with an "Evolutionary Perspective" and end with "Further Phylogenetic Considerations." These sections describe evolutionary relationships within each phylum and evolutionary connections to animals of previous and following chapters. Updated cladograms are used to depict taxonomic relationships. Evolutionary connections and animal adaptations are stressed in the structure and function sections.

To further explain and support evolutionary concepts, a second set of themed boxed readings (in addition to "Wildlife Alerts") entitled "Evolutionary Insights" was added to the sixth edition and has been expanded in this new edition. These boxes provide detailed examples of principles covered in a chapter and provide insight into how evolutionary biology works. For example, chapter 4 includes a reading on big-cat biogeography that illustrates how a variety of sources of evidence are used to paint a picture of the history of one group of animals. Chapter 5 has a reading on the speciation of Darwin's finches that illustrates how and why speciation occurs. Other readings describe ideas regarding animal origins, the debates that occur among taxonomists who try to sort out evolutionary relationships within animal groups, and the evolution of animal organ systems.

To help students understand that science is a process, not just a body of facts, the new type of boxed reading added to the seventh edition has been retained in the eighth. These "How Do We Know" boxes highlight research results that provide insight into biological processes. For example, chapter 3 has a box entitled "How Do We Know about the Function of Genes—Mutagenesis Screening?" This box discusses how biologists use mutations as a tool for investigating the function of genes. Chapter 14 has a box entitled "How Do We Know about Spider Silk?" This box discusses methods for measuring the tensile strength and elasticity of spider silk and the possible uses of engineered silk. The boxed readings in each chapter are listed following the table of contents.

*Zoology* is organized into three parts. Part One covers the common life processes, including cell and tissue structure and function, the genetic basis of evolution, and the evolutionary and ecological principles that unify all life.

Part Two is the survey of protists and animals, emphasizing evolutionary and ecological relationships, aspects of animal organization that unite major animal phyla, and animal adaptations. All of the chapters in Part Two have been updated. The presentation of taxonomic principles in chapter 7, and the taxonomic relationships in chapters 8 through 22, have been carefully revised and incorporate some of the flavor of the exciting changes occurring in the field of taxonomy. You will see some of these changes listed under "New to the Eighth Edition." Cladograms have been updated and, as in previous editions, full-color artwork, photographs, and lists of phylum characteristics are used to highlight each phylum.

Part Three covers animal form and function using a comparative approach. This approach includes descriptions and full-color artwork that depict evolutionary changes in the structure and function of selected organ systems. Part Three includes an appropriate balance between invertebrate and vertebrate descriptions.

## New to the Eighth Edition

As with earlier revisions of *Zoology*, the focus for this revision has been on presenting evolutionary and ecological concepts clearly and accurately. We believe that presenting evolutionary concepts clearly and, using examples from current literature, as convincingly as possible is essential in today's biology courses. The changes that we have made incorporate more examples that illustrate evolutionary principles. No disciplines within zoology have experienced more changes in the last two decades as taxonomy and phylogeny. All of these changes are difficult to incorporate into an introductory textbook. At the same time, the reevaluation of hypotheses of relationships illustrate how dynamic and exciting the field of zoology is. We have taken a conservative, yet up-to-date, position on taxonomic revisions. At the same time we have pointed out where new evidence has altered our view of animal phylogeny and where more changes are likely to come in the future. We have also tried to keep the ecological perspective at the forefront of this book. We have updated "Wildlife Alert Boxes" and added new information on threatened and endangered species and groups. The following are major additions to this edition:

- In response to reviewer suggestions, we have added pronunciations to the "Key Terms" list at the end of each chapter as well as in the Glossary. These pronunciations are placed in a location very accessible to students.
- We have added the most up-to-date phylogenetic evolutionary tree to the inside of the front cover. This tree diagram will allow students immediate and continual reminders of the relationships among the animal phyla they are studying.
- The cladograms have been updated for all chapters in Part Two of the textbook.
- In response to reviewer suggestions, we have added more tools that allow students to review material in the chapter and test their comprehension of text material. The end of each chapter has two types of review questions:
  - "Concept Review Questions" (with answers) include both multiple-choice and true/false questions that can be used in class or by students as they prepare for class and tests.
  - "Analysis and Application Questions" are designed to help students think critically about material presented in a chapter. They often include open-ended questions that can be used in a discussion format in class or in study groups.
- All chapters and boxed readings have been carefully edited. These revisions include minor to substantial changes in wording, artwork, photographs, and content. The following chapters have substantial changes:
  - Chapter 2 includes new sections on microbodies (peroxisomes) and aquaporins. The newly discovered function of primary cilia acting as a signal-receiving "antenna" and symbiogenesis are also new additions. The section on edocytosis has been updated and reorganized.
  - Chapter 4 has expanded coverage of evolutionary adaptation. The boxed reading "How Do We Know Evolutionary Timescales?" has been revised and expanded to include radiometric dating. Additional coverage of vestigial structures has been added to the evidence of evolution.
  - Chapter 5 includes a more detailed example of genetic drift and the bottleneck effect, with the northern elephant seal as an example. A detailed example of disruptive selection and sexual selection using the plainfin midshipman has been added.
  - Chapter 6 includes a new boxed reading "How Do We Know: Local Solutions to Environmental Problems." This box provides practical steps that everyone can take toward alleviating ecological problems. Population statistics have been updated.
  - Chapter 7 has a new emphasis on domain-level classification based on rRNA data. The phylogenetic species concept is introduced. A newer interpretation of higher-level taxonomy based on molecular data is emphasized. This phylogeny is explained in chapter 7 and a summary figure is placed in the inside front cover of the textbook.
  - Chapter 8 has been completely rewritten in accordance with the 2005 reclassification of the Eukarya by the International Society of Protistologists. Emphasis is placed on the medically important protists.
  - Chapter 9 includes updated taxonomy, including the elevation of the Staurozoa to class-level status. It presents a reevaluation of the relationships of the Cnidaria and Ctenophora and the relationships among cnidarian classes—including Staurozoa.
  - Chapter 10 includes coverage of two new phyla: (1) Acoelomorpha and (2) Cycliophora, one of the most recently described phyla, which contains animals that live only on the mouthparts of lobsters.
  - Chapter 11 was formerly chapter 12. The phylum sequence changes in chapters 11 through 13 reflect the current ideas in the relationships between animal phyla. This change keeps all the lophotrochozoans grouped together (chapters 10 through the first half of 13) and all ecdysozoans together (second half of chapters 13 through 15). This chapter has updated coverage of relationships of molluscs to other animals. The section on the origin of coelom has been deleted in response to reviewer comments to make room for new coverage of cephalopod learning.
  - Chapter 12 was formerly chapter 13. This chapter presents new ideas on annelid taxonomy, including the idea that the Polychaeta is a paraphyletic grouping and that three groups, previously considered separate phyla, are most likely annelids: Sipuncula, Echiura, and Siboglinidae (previously known as Pogonophora).
  - Chapter 13 was formerly chapter 11. This placement provides a nice transition into the arthropods (chapter 14), since they molt their cuticles and are more closely related to the arthropods than to the other aschelminths.
  - Chapter 14 contains updated information on the relationships of the arthropods to other animal phyla. It contains new information on spider silk chemistry. New coverage of the Euphausiacea (krill) emphasizes the importance of this group of crustaceans in marine ecosystems and commercial fisheries.
  - Chapter 15 has been extensively revised, including the addition of examples and photographs. It contains updated

information and expanded coverage of insect thermoregulation using the honeybee as an example. Additional coverage of insect sensory systems includes noctuid moth responses to bat echolocation and insect detection of ultraviolet light. Expanded coverage of insect development includes more details on advantages of holometabolous metamorphosis. The discussion of social insects now includes information on haplodiploid sexdetermination and a brief introduction to kin selection. Coverage of insects and humans now includes very recent information on Colony Collapse Disorder in honeybee colonies. A section describing the four big insect orders—Coleoptera, Lepidoptera, Diptera, and Hymenoptera—has been added to help students appreciate the diversity and importance of members of these very large and important insect orders. Additional information on early insect evolution and consideration of the question "Why are there so few marine insects?" has been added.

- Chapter 18 contains updated information on the ever-changing system of fish classification, including consideration of lampreys as vertebrates and dropping "Osteichthyes" as a vertebrate class. The newer classification reflects the monophyly of fishes and tetrapods.
- Chapter 19 contains updated information on amphibian taxonomy, including an emphasis on the tentative nature of amphibian classification. Additional details have been added on amphibian biology throughout the chapter. The section "Amphibians in Peril" has been completely rewritten to reflect the latest ideas on the causes of amphibian declines around the world. A new Wildlife Alert on the extinction of the golden toad of Costa Rica replaces the Wildlife Alert on the red hills salamander. This is very timely because the golden toad episode is largely responsible for drawing the world's attention to the amphibian decline issue.
- Chapter 20 introduces the cladistic interpretation of the Amniota and has been updated with a stronger emphasis on the monophyly of the Amniota and the paraphyletic nature of the traditional classification of the class "Reptilia." The turtles are presented as diapsids, showing evolutionary convergence of their skulls with the anapsid reptiles.
- Chapter 24 includes a new section on the enteric portion of the autonomic nervous system. The section on taste has been updated to include the taste umani. The role of pheromones as chemical signals has been added to the section on smell.
- Chapter 25 includes two new sections: "Some Hormones Are Not Produced by Endocrine Glands" and "Evolution of the Endocrine System."
- Chapter 27 has been updated to include more examples of the diversity in digestive structures. Many new terms are emphasized in bold-faced type. The tables on water-soluble and fat-soluble vitamins have been updated.
- Chapter 28 includes a new section on how the countercurrent heat exchanger works in insects to regulate body temperature during flight. The section on thermal regulation in birds and mammals has been updated to include the latest information on topor and estivation.
- Chapter 29 includes recently discovered examples of parthenogenesis in the Komodo dragon and a species of hammerhead shark, as well as a description of fertilization in cartilaginous fishes. A short section on mammals with estrous cycles has been added.

- As with the previous edition, chapters on cell chemistry, energy and enzymes, embryology, and animal behavior—along with numerous boxed readings and pedagogical elements—have been moved to the website. This content-rich website is located at www.mhhe.com/millerharley8e.

## Acknowledgments

We wish to thank the reviewers who provided detailed analysis of the text during its development. In the midst of their busy teaching and research schedules, they took time to read our manuscript and offer constructive advice that greatly improved the eighth edition.

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Alexander L. Bezzerides, *University of Wisconsin—Barron County*
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The publication of a textbook requires the efforts of many people. We are grateful for the work of our colleagues at McGraw-Hill, who have shown extraordinary patience, skill, and commitment to this textbook: Patrick Reidy, our Sponsoring Editor has helped shape *Zoology* from its earliest planning stages. His wisdom and skill are evident in the eighth edition. Wendy Langerud, Developmental Editor, worked with this textbook on the latest revision. We are grateful for her skill in coordinating many of the tasks involved with publishing this edition of *Zoology*. Wendy kept us on schedule and kept the production moving in the plethora of directions that are nearly unimaginable to us. Tiffany Timmerman served as Project Editor for this edition. We appreciate her efficiency and organization.

Finally, but most important, we wish to extend appreciation to our families for their patience and encouragement. Janice A. Miller

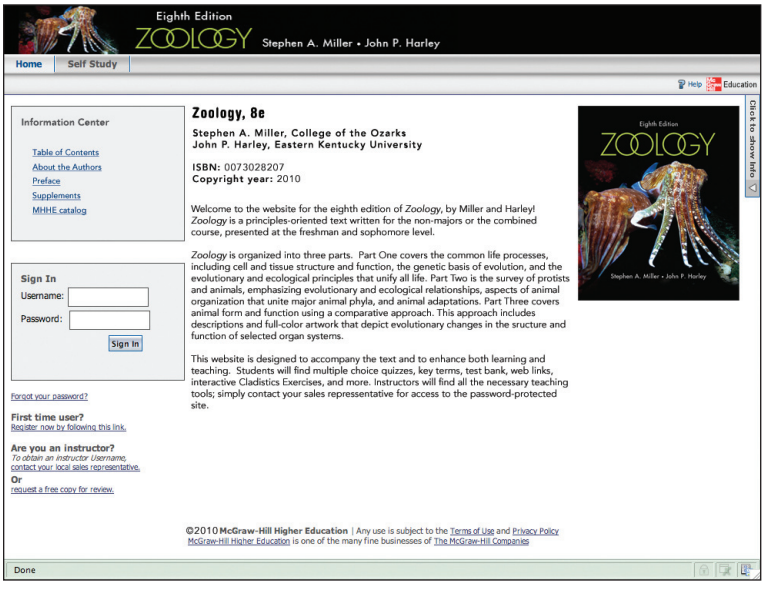
lived with this text through many months of planning and writing. She died suddenly two months before the first edition was released. Our wives, Carol A. Miller and Donna L. Harley, have been supportive throughout the revision process. We appreciate the sacrifices that our families have made during the writing and revision of this text. We dedicate this book to the memory of Jan and to our families.

***STEPHEN A. MILLER***

***JOHN P. HARLEY***

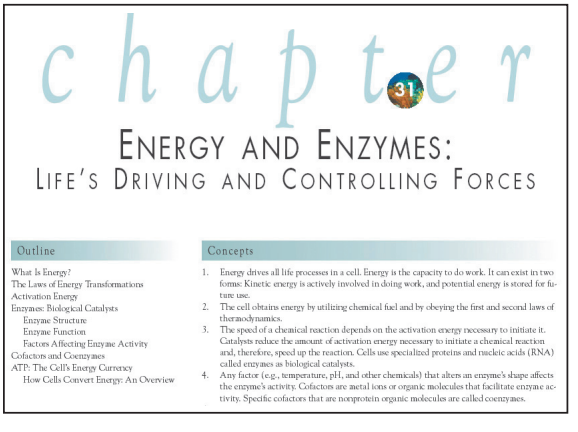
## Supplementary Materials

### *Zoology* Online Learning Center
### www.mhhe.com/millerharley8e




This convenient website takes studying to a whole new level. **Students** will find multiple choice quizzing, animations, web links, interactive cladistics exercises, boxed readings, and more!

**Instructors** will appreciate a password-protected **Instructor's Manual**, **Laboratory Resource Guide**, and access to all of the **illustrations, photographs, and tables** from the text organized by chapter in convenient PowerPoint files.


chapter 31

ENERGY AND ENZYMES:
LIFE'S DRIVING AND CONTROLLING FORCES

Outline

What Is Energy?
The Laws of Energy Transformations
Activation Energy
Enzymes: Biological Catalysts
Enzyme Structure
Enzyme Function
Factors Affecting Enzyme Activity
Cofactors and Coenzymes
ATP: The Cell's Energy Currency
How Cells Convert Energy: An Overview

Concepts

1. Energy drives all life processes in a cell. Energy is the capacity to do work. It can exist in two forms: Kinetic energy is actively involved in doing work, and potential energy is stored for future use.
2. The cell obtains energy by utilizing chemical fuel and by obeying the first and second laws of thermodynamics.
3. The speed of a chemical reaction depends on the activation energy necessary to initiate it. Catalysts reduce the amount of activation energy necessary to initiate a chemical reaction and, therefore, speed up the reaction. Cells use specialized proteins and nucleic acids (RNA) called enzymes as biological catalysts.
4. Any factor (e.g., temperature, pH, and other chemicals) that alters an enzyme's shape affects the enzyme's activity. Cofactors are metal ions or organic molecules that facilitate enzyme activity. Specific cofactors that are nonprotein organic molecules are called coenzymes.

**Additional Online Chapters**

The following chapters (not printed in the text) are available in PDF format:

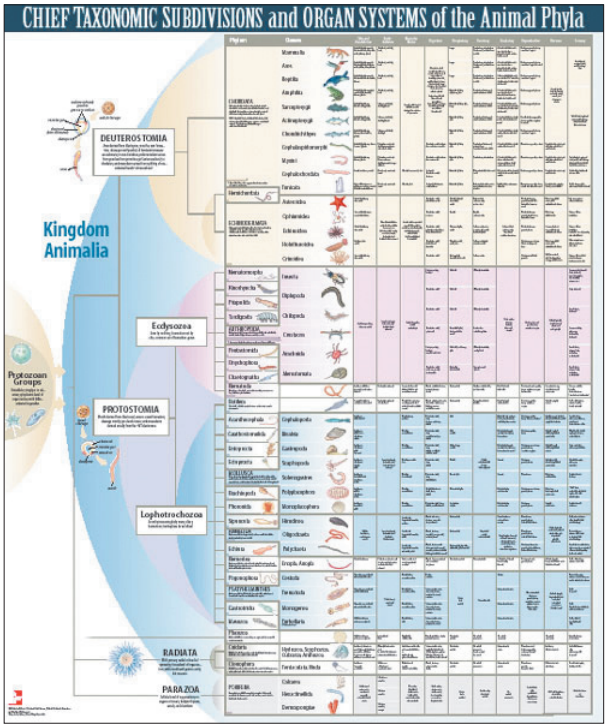
Chapter 30: The Chemical Basis of Animal Life
Chapter 31: Energy and Enzymes: Life's Driving and Controlling Forces
Chapter 32: How Animals Harvest Energy Stored in Nutrients
Chapter 33: Embryology
Chapter 34: Animal Behavior

### Instructor's Manual

Instructors will find lecture outlines and enrichment, teaching suggestions, and suggested readings for each chapter. The Instructor's Manual can be accessed via the password-protected portion of the *Zoology* website.

## Computerized Test Bank

A comprehensive bank of test questions is provided within a computerized test bank powered by McGraw-Hill's flexible electronic testing program EZ Test Online and EZ Test Desktop Version. EZ Test Online allows you to create paper and online tests or quizzes in this easy to use program! A new tagging scheme allows you to sort questions by difficulty level, topic, and section. Imagine being able to create and access your test or quiz anywhere, at any time, without installing the testing software. Now, with EZ Test Online, instructors can select questions from multiple McGraw-Hill test banks or author their own, and then either print the test for paper distribution or give it online. EZ Test Desktop Version has many of these same features, localized on your computer.




## General Zoology Laboratory Manual

Sixth Edition, by Stephen A. Miller, is an excellent corollary to the text. This laboratory manual includes photographs and illustrations, activities on the scientific method, cladistics, ecological and evolutionary principles, and animal structure and function. A **Laboratory Resource Guide** with information on materials and procedures as well as answers to worksheet questions accompanying the lab exercises can be found in the *Zoology* website.


# Additional Resources

## Study Aid/Poster

This 30″ × 36″ poster presenting the Chief Taxonomic Subdivisions and Organ Systems of the Animal Phyla is a great reference/study tool for students!

## NEW! McGraw-Hill: *Biology Digitized Video Clips*

McGraw-Hill is pleased to offer digitized biology video clips on DVD! Licensed from some of the highest-quality science video producers in the world, these brief clips illustrate key biological concepts and processes. Video segments include: alligator predation, clam locomotion, Darwin's finches, frog metamorphosis, mitosis, parasitic wasps, and much more! ISBN-13: 978-0-07-312155-0 (ISBN-10: 0-07-312155-X)

# GUIDED TOUR

*The organization and features of this book have been planned with students' learning and comprehension in mind.*

## CHAPTER CONCEPTS

**Chapter Concepts highlight the main points of the chapter.**

5

## *Evolution and Gene Frequencies*

### CONCEPTS

1. In modern genetic theory, organic evolution is a change in the frequency of alleles in a population.
2. The principles of modern genetics help biologists understand how variation arises.

creases the chances of a population's survival in changing

ics is the study of events occurring in gene pools. The Hardy- n helps scientists understand the circumstances under which Evolution is a result of (a) genetic drift or neutral evolution, mutations that introduce new genes into populations, and/or ion.

rphism occurs when two or more body forms are maintained in a ut a range of phenotypes between them.

unit of classification is the species, and the process by which new eciation.

ccur when gene flow among populations is impeded.

ns, as well as structures within organisms, evolve at different rates. so proceed in jumps, rather than at a constant pace.

sts study DNA and proteins to uncover evolutionary relationships.

n be envisioned as operating in two ways, and both are important tion. One way (e.g., the focus of chapter 4) looks at characteristics of When a population of birds acquires an adaptation through natural ts its members to feed more efficiently on butterflies, the trait is physical characteristics (e.g., bill shape) or inherited behaviors. This selection recognizes that natural selection must act in the context of

however, must be viewed as a vehicle that permits the phenotypic his chapter examines the second way that natural selection operates— utterflies are not permanent—they die. The genes they carry, how- immortal. The result of natural selection (and evolution in general) mmon, or how rare, specific alleles are in a group of animals that are herefore sharing genes.

### Outline


Populations and Gene Pools
Must Evolution Happen?
*The Hardy-Weinberg Theorem*
Evolutionary Mechanisms
*Population Size, Genetic Drift, and Neutral Evolution*
*Gene Flow*
*Mutation*
*Natural Selection Reexamined*
*Balanced Polymorphism and Heterozygote Superiority*
Species and Speciation
*Allopatric Speciation*
*Parapatric Speciation*
*Sympatric Speciation*
Rates of Evolution
Molecular Evolution
*Gene Duplication*
Mosaic Evolution




6. The skeletal and muscular systems of amphibians are adapted for movement on land.
7. Amphibians are carnivores that capture prey in their jaws or seize them with their tongues.
8. The circulatory system of amphibians is modified to accommodate the presence of lungs, gas exchange at the skin, and loss of gills in most adults.
9. Gas exchange is cutaneous, buccopharyngeal, and pulmonary. A buccal pump accomplishes pulmonary ventilation. A few amphibians retain gills as adults.
10. Sensory receptors of amphibians, especially the eye and ear, are adapted for functioning on land.
11. Amphibians excrete ammonia or urea. Ridding the body of excess water when in water and conserving water when on land are functions of the kidneys, the skin, and amphibian behavior.
12. The reproductive habits of amphibians are diverse. Many have external fertilization and development. Others have internal fertilization and development. Courtship, vocalizations, and parental care are common in some amphibians. The nervous and endocrine systems control metamorphosis.
13. Local habitat destruction, disease, global warming and other unknown causes are resulting in an alarming reduction in amphibian populations around the world.
14. An egg that is resistant to drying evolved in the amniote lineage, which is represented today by reptiles, birds, and mammals.

### SELECTED KEY TERMS

amniotic egg (am′ne-ot′ik) (p. 325)
amplexus (am-plek′sus) (p. 321)
buccal pump (buk′el) (p. 318)
buccopharyngeal respiration (buk′o-fah-rin′jel res′pah-ra′shun) (p. 318)
cutaneous respiration (kyoo-ta′ne-us res′pah-ra′shun) (p. 318)
Lissamphibia (lis′am-fib′e-ah) (p. 310)
nictitating membrane (nik′ti-tat-ing mem′bran) (p. 320)
tetrapods (te′trah-podz) (p. 310)

### CONCEPT REVIEW QUESTIONS

1. The group of animals that contains only living amphibians is
   a. Stegocephalia.
   b. Tetrapoda.
   c. Lissamphibia.
   d. Amniota.
2. The order _____ is comprised of the salamanders.
   a. Caudata
   b. Anura
   c. Gymnophiona
3. The order _____ is comprised of the frogs and toads.
   a. Caudata
   b. Anura
   c. Gymnophiona
4. Most members of this order have internal fertilization without copulation and some are paedomorphic.
   a. Caudata
   b. Anura
   c. Gymnophiona
5. Adult amphibians are carnivores, feeding on a variety of invertebrates and, in some cases, small vertebrates. Larval amphibians virtually all feed on aquatic invertebrates.
   a. True
   b. False

### ANALYSIS AND APPLICATION QUESTIONS

1. How are the skeletal and muscular systems of amphibians adapted for life on land?
2. Why is the separation of oxygenated and nonoxygenated blood in the heart not as important for amphibians as it is for other terrestrial vertebrates?
3. Explain how the skin of amphibians is used in temperature regulation, protection, gas exchange, and water regulation. Under what circumstances might cooling interfere with water regulation?
4. In what ways could anuran vocalizations have influenced the evolution of that order?
5. What steps should be taken to save imperiled amphibians? Name some things that you can do.

### ZOOLOGY WEBSITE

The *Zoology* Website is a great place to check your understanding of chapter material. Visit www.mhhe.com/millerharley8e for access to a variety of helpful learning tools!

- A list of **Selected Key Terms** and pronunciations includes page references for further review.
- **Analysis and Application Questions** help students synthesize chapter information.
- **Concept Review Questions** help students understand and review the material in each chapter.
- A web address directs students and instructors to the ***Zoology* Online Learning Center** for chapter-specific study tools.

## How Do Zoologists Investigate the Inner Workings of the Tiny Structures within a Cell?

The small size of cells is the greatest obstacle to discovering their nature and the anatomy of the tiny structures within cells. The evolution of science often parallels the invention of instruments that extend human senses to new limits. Cells were discovered after microscopes were invented, and high-magnification microscopes are needed to see the smallest structures within a cell. Most commonly used are the **light microscope,** the **transmission electron microscope (TEM),** the **scanning electron microscope,** the **fluorescence microscope,** the **scanning tunneling microscope,** and the **atomic force microscope.**

Microscopes are the most important tools of **cytology,** the study of cell structure. But simply describing the diverse structures within a cell reveals little about their function.

Today's modern cell biology developed from an integration of cytology with **biochemistry,** the study of molecules and the chemical processes of metabolism. Throughout this book, many photographs are presented using various microscopes to show different types of cells and the various tiny structures within. From these photographs it will become apparent that similarities among cells reveal the evolutionary unity of life.

- **How Do We Know** boxes provide an understanding of how biologists have arrived at conclusions regarding a variety of biological processes.

- **Evolutionary Insights** boxes feature detailed examples of principles covered in the chapter and offer insight into how evolutionary biology works.

### EVOLUTIONARY INSIGHTS

#### The Animal-Like Protists May Lie at the Crossroads between the Simpler and the Complex

Between the unicellular microorganisms (Eubacteria and Archaea) and the multicellular eukaryotes lie the protists. The protists may represent a bridge from simple to complex life-forms. As noted in this chapter, most protists are single eukaryotic cells that provide some insight as to what the earliest eukaryotes might have been like.

Along these lines, protists are of interest to evolutionary biologists because current organisms may retain clues to important milestones in eukaryotic evolution. For example, a group of protists called jakobids have mitochondria that resemble bacteria more than those of any other type of eukaryote. Therefore, jakobids may resemble those microorganisms that lived shortly after cells acquired aerobic bacteria as endosymbionts (*see box in chapter 2*). At the other end of the evolutionary spectrum are the choanoflagellates (a group of free-living zooflagellates found primarily in freshwater). Many choanoflagellate species are sessile, being permanently attached to a substrate (box figure 8.1). Each individual bears a single flagellum that bears an uncanny resemblance to the "collar cells" of sponges (*see figure* 9.5)—the simplest animals. Commonly, individuals are stalked and/or embedded in a gelatinous secretion. Most species are colonial and immobile. Members of the genus *Proterospongia* form (planktonic) colonies of up to several hundred cells and bear a striking resemblance to primitive sponges. Whether this simple relationship reflects a true phylogenetic relationship and crossroads between the unicellular flagellates and the more complex multicellular sponges or whether the similarities are a product of independent, convergent evolution is not certain. Definitive answers will have to await nucleic acid sequencing, which provides a more objective measure of relatedness than comparing possible superficial appearances.

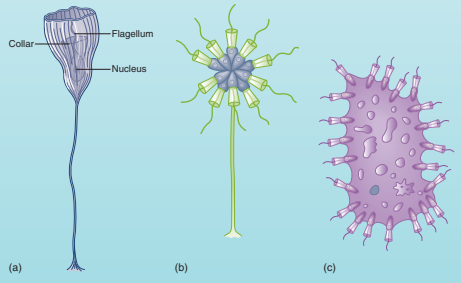



**FIGURE 8.1 Zooflagellate Diversity.** Choanoflagellates: (*a*) *Stephanoeca*. (*b*) *Codosiga*, a colonial species. (*c*) *Proterospongia*, another colonial , with individuals embedded in a thick, gelatinous matrix.


### WILDLIFE ALERT

Red-Cockaded Woodpecker (*Picoides borealis*)

**VITAL STATISTICS**

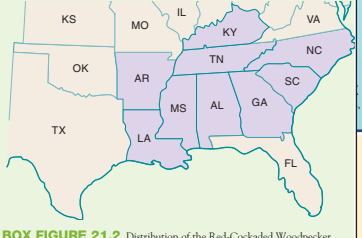
**Classification:** Phylum Chordata, class Aves, order Piciformes, family Picidae

**Range:** Fragmented, isolated populations where southern pines exist in the United States, (Alabama, Arkansas, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee)

**Habitat:** Open stands of pines with a minimum age of 80 to 120 years

**Number remaining:** Approximately 7,500 birds

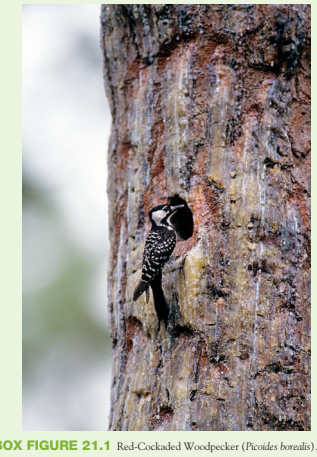
**Status:** Endangered throughout its range




**BOX FIGURE 21.2** Distribution of the Red-Cockaded Woodpecker (*Picoides borealis*).

**NATURAL HISTORY AND ECOLOGICAL STATUS**

Red-cockaded woodpeckers are 18 to 20 cm long with a wingspan of 35 to 38 cm. They have black-and-white horizontal stripes on the back, and their cheeks and underparts are white (box figure 21.1). Males have a small, red spot on each side of their black cap. After the first postfledgling molt, fledgling males have a red crown patch. The diet of these woodpeckers consists mostly of insects and wild fruit.



**BOX FIGURE 21.1** Red-Cockaded Woodpecker (*Picoides borealis*).

Eggs are laid from April through June, with females utilizing their mate's roosting cavity as a nest. The average clutch size is three to five eggs. Most often, the parent birds and one or more male offspring from previous nests form a family unit called a group. A group may include one breeding pair and as many as seven other birds. Rearing the young becomes a shared responsibility of the group.

The range of red-cockaded woodpeckers is closely tied to the distribution of southern pines, with open stands of trees in the 80- to 120-year-old group being the favored nesting habitat (box figure 21.2). Dense stands or hardwoods are usually avoided. The woodpeckers excavate roosting cavities in living pines, usually those infected with a fungus that produces what is known as red-heart disease. The aggregate of cavity trees is called a cluster and may include 1 to 20 or more cavity trees on 3 to 60 acres. Completed cavities in active use have numerous small resin wells, which exude sap. The birds keep the sap flowing, apparently as a cavity defense mechanism against rat snakes and other predators. The territory for a group averages about 200 acres.

The decline of red-cockaded woodpecker populations is due primarily to the cutting of pine forests with trees that are 80 years or more old and the encroachment of hardwood understories. Recommendations for management and protection include: survey, monitor, and assess the status of individual populations and the species; protect and manage nesting and foraging habitats on federal lands; encourage protection and management on private lands; and inform and involve the public.

- **Wildlife Alert** boxes discuss issues related to endangered and threatened species of animals.